On the Interdependencies of Supporting, Monitoring, and Assessing Agents

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Abstract: This paper shows that an employer's two roles of supporting employees as well as assessing their abilities and making appropriate replacement decisions are inextricably intertwined. Offering support in the form of advice, resources, time, or freedom not only helps the worker to succeed in his job but either impedes or facilitates the assessment of his ability. This interaction has broad implications for the principal's optimal choices of support and monitoring, the sensitivity of turnover to performance, moral hazard concerns, optimal incentive contracting, agent rents, and firm value. I apply the model to study why corporate boards that are more capable advisors make CEO replacement decisions that are less sensitive to performance and "tolerate" larger CEO rents, why tech companies such as Google "pamper" their engineers with seemingly excessive support and loose monitoring, why junior faculty members are protected from high teaching loads and service, and why headquarters may distort capital budgets even when division managers have no private information about their investment opportunities.

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1 Introduction

Supporting employees plays a critical role in organizations. Depending on the context, support can come in different forms such as advice, resources, time, and freedom, but with the common goal of helping employees to be successful in their job. Examples abound: Corporate boards advise and counsel CEOs on strategy development and implementation; headquarters allocate resources to divisions, enabling them to develop and promote new products; tech companies such as Google give engineers time and freedom to tinker on new projects of their choosing, etc. These types of support are costly, but help foster the goals of the organization such as improving strategy, facilitating successful project launches, and boosting innovation.

In this paper, I point out a more subtle effect of support: since support affects the employee's performance, it affects the processes and effectiveness with which the superior assesses the worker's ability and fit. Assessment is important because it allows superiors to replace those workers that are a poor fit for the needs of the organization and to retain those that are a good fit. The model shows that support either impedes or facilitates performance-based assessment, depending on whether it has a stronger positive impact on low-ability or high-ability workers. This interaction, in turn, has implications not only for the optimal level of support, but also for the superior's incentive to engage in monitoring, the sensitivity of turnover to performance, the worker's incentive to exert effort, the cost of contracting, the worker's utility (rents), and firm value.

To elaborate, I develop a model in which a principal hires an agent to exert effort to work on a task (e.g., run the firm, develop new investment ideas or technologies, promote products). An important function of the principal is to assess the agent's ability to perform this task and to decide whether to retain him for a second period. As in Holmstrom (1999), the agent's ability is unknown initially to all parties. One way to learn about the agent is to draw inferences from output. The informativeness of output with respect to ability, however, is not exogenous. When the principal supports the agent with resources, freedom, time, or advice, she not only improves his chances of success, but also changes the usefulness of output in guiding the replacement decision (the applications discussed below give more specific examples). Specifically, when the replacement decision is based on performance, the principal makes two mistakes: she replaces a high-ability agent who happens to perform poorly (I refer to this mistake as undue replacement) and retains a low-ability agent who happens to perform well (undue retention). Support helps the agent to be successful and hence reduces the expected cost of undue replacement, but increases the expected cost of undue retention. The analysis shows that if support has a stronger positive impact on high-ability than on low-ability agents, support reduces the expected cost of undue replacement faster than it increases the expected cost of undue retention, and hence renders output more useful in guiding the principal's replacement decision. However, if support has a stronger impact on low-ability rather than high-ability agents, the result flips: then, support reduces the expected cost of undue replacement less quickly than it increases the expected cost of undue retention, and impedes output-based replacements. Finally, if the impact of support is independent from ability, support does not change the quality of performance-based replacements.

The principal does not have to rely solely on performance to assess the agent. Following Cremer (1995), Hermalin and Weisbach (1998), and Hermalin (2005), I assume that the principal can engage in unobservable monitoring activities to obtain additional information about the agent's ability and fit. The principal's incentive for monitoring depends on the support environment. Specifically, in environments in which support has a relatively stronger impact on high-ability than low-ability agents, heightened support renders output more useful for the replacement decision and weakens the principal's incentive to obtain additional information via monitoring. In contrast, if support has a relatively stronger impact on low-ability than high-ability agents, greater support renders output less decision useful, and increases the principal's incentive to monitor. The effect of support on monitoring plays an important role because it creates an indirect link between support and the agent's effort incentive as discussed next.

There are two sources of incentives that cause the agent to expand effort. First, the principal designs a formal contract that rewards high performance. Second, the agent understands that if the principal does not learn his ability via monitoring, she will draw inferences from observed performance. The agent is therefore eager to succeed not only to obtain the bonus, but also to impress the principal and to increase the chances of being retained for a second period (see also Cremer, 1995). The stronger the incentive effect associated with the agent's career concern, the lower is the need for costly incentive pay and the lower is the agent's expected compensation. The important point here is that the principal can influence the agent's career incentive through her observable choice of support. As discussed, the magnitude of support determines the usefulness of performance in guiding the replacement decision and thus the marginal value of monitoring. By adjusting the level of support, the principal can credibly convey to the agent that her own down-the-road temptation for monitoring will be weak. Knowing that loose monitoring translates into the principal being more reliant on performance in assessing the agent's ability, the agent is more eager to perform well so as to improve the perception of his ability. In short, support serves the principal as a tool to commit to loose monitoring, which fosters the agent's career incentives and reduces expected compensation. Other articles that study related commitment issues, in contrast, focus on ex ante actions that increase the marginal cost of information acquisition (rather than reduce its marginal value) such as installing an ineffective monitoring or accounting system (e.g., Cremer, 1995; Aghion and Tirole, 1997; Arya, Glover, and Sivaramakrishnan, 1997).[1]

To discuss the implications of this analysis, I consider three applications of the model. The key difference in these examples is with respect to whether support has a greater impact on high or low-ability agents.

Corporate boards: Two main responsibilities of corporate boards are to advise CEOs on key strategic decisions as well as to assess their ability and fit and to replace them if necessary (Mace, 1971; Vancil, 1987). Providing advice helps the CEO to succeed but, arguably, is more useful for low-ability CEOs than for high-ability ones. As a consequence, the very act of advising the CEO renders it harder for the board to assess his ability based on observed firm performance.[2] The model predicts that relative to what would be optimal if advice had no effect on assessment (which I use as a benchmark), the board optimally limits its advice for two reasons: to improve performance-based replacement decisions, which increases long-term firm performance, and to indirectly commit to a weaker monitoring intensity, which strengthens the CEO's effort incentive. The limited advice, however, comes

[1] See also Burkart, Gromb, and Panunzi (1997) who show that dispersed outside ownership can serve as a commitment for loose monitoring.

[2] Adams and Ferreira (2007) also study a conflict between the different roles of boards but in a very different setting. In their model, the CEO possesses private information that the board has to elicit in order to be able to provide advice. Since the board can also use this information to interfere with the CEO's project choice, the CEO may be reluctant to share the relevant information, inhibiting board advice. See also Holmstrom (2005) for a similar argument. Raheja (2005), Harris and Raviv (2008), and Baldenius et al. (2014) consider settings in which directors are assumed to have private information and preferences that make them either good advisors or good monitors, but not both.

at the cost of lower short-term performance. In addition, the model predicts that boards that are more capable advisors (due to their expertise and background) not only offer more advice but also engage in more monitoring, exhibit a weaker turnover-to-performance sensitivity, and "tolerate" greater CEO rents. The model therefore suggests that the empirical evidence of a positive relation between outside director representation on boards and the sensitivity of CEO turnover to performance (e.g., Weisbach, 1988) does not necessarily imply that outsiders play a crucial governance role as is typically argued but can merely reflect the outsiders' weaker ability to provide advice, which changes the processes with which the board assesses and replaces executives.

Tech companies: Tech companies such as Google support their engineers by giving them time, resources, and freedom to pursue innovative ideas. A good example is Google's so called "20 percent" policy that allows their engineers to spend 20% of their work time on company-related projects of their choosing. This type of support boosts innovation, but presumably has a greater impact on high-ability engineers who have clever ideas than on low-ability engineers who have no ideas. As a consequence, support gives high-ability engineers more room to separate themselves from low-ability engineers and facilitates performance-based assessment. This effect, in turn, reduces the superior's need to acquire information about ability via monitoring. The model therefore provides an additional explanation for why tech companies "pamper" their employees with seemingly over-the-top support and loose monitoring. Maybe surprisingly, the model also shows that the combination of strong support and loose monitoring translates into low employee rents, rather than high rents. A similar argument applies to academic environments. Junior faculty members – whose abilities are uncertain initially – are typically shielded from high teaching loads and time consuming committees. By giving rookies the opportunity to focus on their research, there are fewer excuses and output becomes more useful in assessing the new hire's talent. This effect lowers the need for monitoring, which, in turn, ties the replacement decision closer to performance and reduces the pressure on costly incentive pay.

Capital budgeting: I also apply the analysis to capital budgeting settings in which a benevolent headquarters allocates resources to a division manager. Here, a larger capital allocation can have a negative or positive effect on output-based ability assessment, depending on the particular situation. Relative to what would be optimal if resources had no effect on assessment, headquarters optimally distorts the capital allocation either upwards or downwards. While the extant literature on capital budgeting explains distortions as a result of the manager being privately informed about investment opportunities and conflicts of interests such as empire building preferences (e.g., Antle and Eppen, 1985; Harris and Raviv, 1996; Bernado, Cai, and Luo, 2001), the argument here is based on the notion that capital allocations serve assessment and commitment roles.

The remainder of this paper is organized as follows. In sections 2 and 3, I present the model and discuss the principal's optimization problem. I then study how support affects performance-based replacements (Section 4.1), the principal's incentive to monitor (Section 4.2), the agent's effort incentive and the cost of the incentive contract (Section 4.3), and characterize the equilibrium solution (Section 4.4). Section 5 discusses several applications of the model and Section 6 concludes. All proofs are in Appendix B.

2 The Model

A risk-neutral principal hires a risk-neutral agent to carry out a task. The agent could be the CEO of the firm or a division manager and the principal could be the board of directors (acting in the best interests of shareholders) or the firm's headquarters. Alternatively, the principal could be a top manager in a firm or the dean of a college and the agent could be an engineer or faculty member. A key feature of the model is that the agent's chances to be successful in his new position depend on his actions and ability (as discussed below) as well as the level of support, denoted $I \in [0,1]$, provided by the principal. Depending on the context, support comes in different forms such as advice, freedom, or capital, but with the common goal of helping the agent to succeed in his new position.

The model has two periods and five stages:

Stage 1: In the beginning of the first period, the principal hires a new agent who is either of high ability, $\theta = G$, or low ability, $\theta = B$. The prior probability of $\theta = G$ is commonly known to be $p \in (0,1)$. Neither the principal nor the agent knows θ initially. The principal publicly chooses a level of support I, which costs the principal $C(I)$, with $C'(I) > 0$, $C''(I) > 0$, and $C'(1) \to \infty$. The principal also offers the agent an at-will contract (w_H, w_L), where w_H and w_L are the payments for first-period success and failure, respectively, (success and failure are defined below). The agent is protected by limited liability in the sense that payments must be nonnegative, $w_H, w_L \geq 0$, and is willing to join the firm if his expected payoff exceeds or equals his reservation utility of zero. Due to the limited liability assumption and the effort control problem, the agent always enjoys an utility above his reservation utility such that the participation constraint can be ignored.

Stage 2: During the first period, the agent makes an unobservable effort choice, $a \in \{a_L, a_H\}$, with $1 \geq a_H > a_L \geq 0$. The agent's private cost of effort a is $K(a)$. High effort is costly, whereas low effort is not; $K(a_H) = k > 0$ and $K(a_L) = 0$. Throughout the analysis, I assume that k is sufficiently small to ensure that inducing effort is optimal. At the same time, the principal engages in costly monitoring, denoted $m \in [0, 1]$, in an attempt to learn the incumbent's ability θ. Conditional on monitoring m, the principal obtains a signal that reveals θ with probability m and does not obtain the signal with probability $(1 - m)$. The monitoring effort and the signal are neither contractible nor observable to the agent. The cost associated with monitoring to the principal is $0.5\gamma m^2$, with γ sufficiently high to ensure an interior solution, $m < 1$.

Stage 3: The agent's ability, θ, his effort choice, a, and the level of support, I, jointly determine the distribution of the output, denoted x, at the end of the first period. The payoff x is either $x = X > 0$ (success) or $x = 0$ (failure). The probability of success, $x = X$, conditional on a, θ, and I is specified by

$$P(X|a, \theta, I) = a \cdot \phi(\theta, I). \tag{1}$$

I make two assumptions regarding the differences between high-ability and low-ability agents. First, $1 > \phi(G, I) > \phi(B, I) \geq 0$ for all I, that is, a high-ability agent is more likely to succeed than a low-ability agent, regardless of the level of support I. Second, $\partial\phi(\theta, I)/\partial I = z_\theta$, with $z_\theta \in [0, 1]$. The variable z_θ represents the marginal effect of support on the productivity of an agent with ability θ. z_G can be larger or lower than z_B. If $z_G > z_B$, support has a greater impact on high-ability agents than on low-ability agents, and for $z_G < z_B$, the opposite is true. To satisfy these two assumptions, I use the following specification:

$$\phi(\theta, I) = \theta + z_\theta I, \tag{2}$$

with $\theta \leq 0.5$ and $z_\theta \leq 0.5$, for $\theta = B, G$, and $G > B \geq 0$ and $G + z_G I \geq B + z_B I$ for $I = 1$.

The assumption that $P(X|a, \theta, I)$ is multiplicative in effort a and $\phi(\theta, I)$ deserves some discussion. The principal uses the output x to draw inferences about both the agent's ability θ and the agent's effort choice a. Since the aim of the paper is to study how support affects the usefulness of output to infer ability θ, and how this inference affects agency problems, I wish to suppress any direct effects of I on the usefulness of x for inferring effort a. This is achieved by using the multiplicative function in (1).[3] Otherwise, if support directly increases (decreases) the informativeness of output as a signal for effort, greater support would trivially reduce (increase) the cost of inducing effort.

Stage 4: After observing output x, the principal chooses whether to retain the incumbent for a second period or whether to hire a new agent, whose ability is again high with probability p. The principal cannot commit to any replacement/retention policy up front and therefore replaces (retains) the agent if his perceived ability is below (above) the expected ability of the replacement. Following Hermalin and Weisbach (1998) and others, I assume that the agent has a desire to keep his position because he enjoys a private benefit of control, β, in the second period. If the incumbent is fired after the first period, he receives no benefit. An alternative to private benefits is to assume that the principal also has to provide the agent with incentives to work hard in the second period, which together with the limited liability assump-

[3] In Appendix A, I discuss the case in which the principal does not have an option to replace or retain the agent and show that the expected cost of the incentive pay plan is independent of support.

tion implies that the agent can enjoy second-period rents.[4] Again, in this case, the agent has a preference for keeping his position to obtain these rents. This alternative modeling choice does not change the qualitative results of the model.

Stage 5: For simplicity, I do not consider any further actions in the second period and assume that the expected second-period outcome depends on the ability of the agent in charge of this period. Specifically, the expected second-period payoff is R_G or R_B if the agent's ability is high or low, respectively, with $R_G > R_B \geq 0$. Thus, if the principal hires a new agent at the beginning of the second period, expected second-period payoff is

$$R_N \equiv pR_G + (1-p)R_B. \tag{3}$$

$R_\Delta \equiv R_G - R_B$ captures the importance of having a talented agent in the second period and hence the importance of making a good replacement decision.

3 The Optimization Problem

Replacement: The principal's optimal replacement strategy at the end of the first period is as follows. If the principal learns the agent's ability θ through monitoring (with probability m), she will retain him for a second period if he is of high ability and replace him otherwise. If the principal remains ignorant (with probability $1-m$), she will base the replacement decision on observed performance x. Conditional on observing low or high output, the principal revises her beliefs that the incumbent is

[4]The agent obtains these rents regardless of whether he is a replacement or the incumbent.

talented to

$$P(\theta = G|x = 0, I) = \frac{p(1 - a_H\phi(G, I))}{(1 - pa_H\phi(G, I) - (1 - p)a_H\phi(B, I))}, \text{ or} \tag{4}$$

$$P(\theta = G|x = X, I) = \frac{p\phi(G, I)}{(p\phi(G, I) + (1 - p)\phi(B, I))}, \tag{5}$$

respectively. Note that the assumption $\phi(G, I) > \phi(B, I)$ implies $P(\theta = G|x = 0, I) < p$ and $P(\theta = G|x = X, I) > p$. That is, low performance sheds an unfavorable light on the incumbent's perceived ability, whereas the opposite is true for high performance. Accordingly, the principal retains the incumbent if $x = X$, and replaces him with a new agent if $x = 0$.

Monitoring effort: During the first period (stage 2) the principal privately chooses the level of monitoring m to learn about the agent's ability. Monitoring is useful because it allows the principal to make better replacement decisions, which, in turn, leads to a higher expected performance in the second period. Specifically, the principal chooses the level of monitoring that maximizes:

$$\Pi(m, I) = (pR_G + (1 - p)R_N) - (1 - m)(Q_G + Q_B) - 0.5\gamma m^2, \tag{6}$$

with

$$Q_G = p(1 - a_H\phi(G, I))(R_G - R_N)$$

$$Q_B = (1 - p)a_H\phi(B, I)(R_N - R_B).$$

The term $(pR_G + (1 - p)R_N)$ in (6) is the expected second-period output in an ideal world in which the principal always learns the agent's ability. In this case, the principal retains the incumbent if he is talented and replaces him if he is untalented.

However, with probability $(1-m)$, the principal remains ignorant and bases her replacement decision on observed output. Since output is not a perfect indicator of ability, there are two potential mistakes the principal can make. With probability $p(1-a_H\phi(G,I))$ the agent is talented but nevertheless performs poorly, causing the principal to replace him. I refer to this mistake as "undue replacement". With probability $(1-p)a_H\phi(B,I)$ the agent is untalented but nevertheless succeeds, which causes the principal to retain him. I refer to this mistake as "undue retention". The expected costs of undue replacement and undue retention are captured by Q_G and Q_B, respectively. Finally, the last term in (6) is the principal's cost of monitoring. Taking the first order condition on (6) and using $R_N = pR_G + (1-p)R_B$ and $R_\Delta = R_G - R_B$ yields the principal's optimal level of monitoring as a function of the level of support:

$$m^*(I) = p\,(1-p)\,[1 - a_H\,(\phi(G,I) - \phi(B,I))]\,R_\Delta/\gamma. \tag{7}$$

Agent effort: Anticipating the principal's choices regarding monitoring and replacement, the agent's expected utility over the two periods as a function of support I and effort a is given by

$$\begin{aligned} U(I,a) \quad = \quad & P(X|I,a)w_H + (1 - P(X|I,a))w_L - K(a) \\ & + (pm^* + (1-m^*)P(X|I,a))\,\beta, \end{aligned} \tag{8}$$

with $P(X|I,a) = a\,(p\phi(G,I) + (1-p)\phi(B,I))$.

The agent's utility function in (8) can be explained as follows. The first line represents the agent's expected compensation minus the cost of effort. The second line captures the utility the agent expects to receive in the second period. The incumbent knows that the principal will retain him if monitoring reveals that he is talented or if monitoring fails but the first-period output is high. As a consequence, the agent's effort choice not only affects his compensation but also the probability that he retains his position and earns private benefits β. The agent chooses to work hard if the incentive compatibility constraint $U(I, a_H) \geq U(I, a_L)$ is satisfied.

Choice of Support: At the beginning of the first period (stage 1), the principal publicly chooses the level of support that maximizes her expected utility over the two periods. The principal solves the following problem:

$$\begin{aligned} \underset{I}{Max}\, V(I) \;\; &\equiv \;\; P(X|I, a_H)\,(X - w_H) \\ &\quad - (1 - P(X|I, a_H))\, w_L - C(I) + \Pi(m, I), \end{aligned} \tag{9}$$

subject to the agent's effort incentive constraint $U(I, a_H) \geq U(I, a_L)$ (which is binding in the optimal solution) and the principal's optimal monitoring choice at stage 2, given in (7).

4 Analysis

4.1 Effect of support on expected output

I start the analysis by determining how a change in support affects the expected output over the two periods, holding the level of monitoring m and the pay plan (w_H, w_L) constant. Taking the partial derivative of (9) with respect to I yields:

$$\frac{\partial V(I,m,w_H,w_L)}{\partial I} = \underbrace{a_H\left(pz_G+(1-p)z_B\right)X}_{\text{production role}} - C'(I) \\ +\underbrace{(1-m)p\left(1-p\right)a_H\left(z_G-z_B\right)R_{\Delta}}_{\text{assessment role}}. \tag{10}$$

Support helps the agent to succeed in the first period and thereby increases expected first-period output. This "production role" of support is captured by the first term in (10). Equating the production role term with the marginal cost of support $C'(I)$ and solving for I yields the support level that would be optimal if the principal did not have an option to replace or retain the incumbent (see Appendix A for details). However, support plays a second role here, an assessment role. Specifically, support affects the principal's ability to assess the incumbent and to make appropriate replacement decisions based on first-period performance. Better replacement decisions, in turn, improve the expected second-period performance. This assessment role is captured by the second line in (10).

Since the production role of support is straightforward, I focus on the assessment role of support for the rest of this section. The next proposition shows how support affects second-period performance via its impact on the principal's replacement decision.

Proposition 1 *Holding all else equal, for $z_G > z_B$ ($z_G < z_B$), an increase in support improves (deteriorates) performance-based replacement decisions and thereby increases (decreases) expected second-period payoff. For $z_G = z_B$, support plays no assessment role and does not affect second-period performance.*

Support helps the agent to succeed and therefore improves his chances of keeping his job. This effect reduces the probability that a high-ability agent generates a low outcome and hence reduces the expected cost of undue replacement, but it also increases the probability that a low-ability agent generates a high outcome and thus increases the expected cost of undue retention.[5] If support has a stronger marginal impact on high-ability agents than on low-ability ones, $z_G > z_B$, an increase in support reduces the cost of undue replacement faster than it increases the cost of undue retention. In this case, offering greater support renders output more useful for the replacement decision and thereby increases the expected second-period payoff. Conversely, if support has a greater marginal impact on low-ability rather than high-ability agents, $z_G < z_B$, supports increases the cost of undue retention more quickly than it reduces the cost of undue replacement. In this case, greater support reduces the usefulness of output in guiding the replacement decision and reduces expected second-period payoff. Finally, if support has the same effect on low-ability and high-ability agents, $z_G = z_B$, the change in the cost of undue replacement equals the change in the cost of undue retention and support has no impact on second-period performance. The distinction between these cases will play a key role for the analysis that follows.

4.2 Effect of support on monitoring

Uncovering the agent's ability through monitoring is valuable to the principal because it allows her to make better replacement decisions. In this subsection, I am interested in the question of how a change in support changes the principal's optimal level of monitoring. Taking the first derivative of the principal's monitoring choice with

[5] Because a newly hired agent in the second period generates an expected output of $R_N = pR_G + (1-p)R_B$, we obtain $\left(\frac{dQ_G}{dI} + \frac{dQ_B}{dI}\right) = -p\,(1-p)\,R_\Delta a_H\,(z_G - z_B)$.

respect to support yields:

$$dm^*/dI = -p\,(1-p)\,a_H\,(z_G - z_B)\,R_\Delta/\gamma. \tag{11}$$

Condition (11) leads to the next proposition.

Proposition 2 *The principal's optimal monitoring intensity, m^*, decreases with support, I, if $z_G > z_B$, increases with I if $z_G < z_B$, and is independent of I if $z_G = z_B$.*

The value of monitoring to the principal depends on her ability to make appropriate replacement decisions if the only available information is output. As shown in Proposition 1, the usefulness of output in guiding the replacement decision can either increase or decrease in the level of support. Specifically, when $z_G > z_B$, offering greater support allows the principal to make better performance-based replacement decisions and thus weakens her incentive to obtain additional information via monitoring. Conversely, when $z_G < z_B$, support impedes performance-based replacement decisions and strengthens monitoring incentives. In contrast, for $z_G = z_B$, support plays no assessment role and hence does not change the principal's monitoring incentive.

4.3 Effect of support on contracting

In the beginning of the game, the principal offers the agent a pay plan (w_H, w_L) that ensures that he has sufficient incentives to choose action a_H rather than a_L. The next proposition determines the optimal incentive pay plan and the cost of compensation as a function of support I.

Proposition 3 *The optimal pay plan $(w_H^*(I), w_L^*)$ and the expected compensation, denoted $\Psi^*(I)$, as a function of support I are given by*

$$\begin{aligned} w_H^*(I) &= \frac{k}{(a_H - a_L)\left(p\phi(G,I) + (1-p)\phi(B,I)\right)} - (1-m^*)\,\beta, \qquad (12) \\ w_L^* &= 0, \text{ and} \end{aligned}$$

$$\begin{aligned} \Psi^*(I) &= P(X|I,a_H)w_H^* + (1 - P(X|I,a_H))w_L^* \qquad (13) \\ &= \frac{a_H k}{(a_H - a_L)} - P(X|I,a_H)(1-m^*)\beta, \end{aligned}$$

respectively. The bonus w_H^* and the expected compensation Ψ^* decline with the retention benefit β.

Proposition 3 shows that the optimal pay plan is a function of the control benefit β the agent enjoys when he retains his job. This result follows because the prospect of staying in charge and receiving β serves as an important source of incentives in the first period. The agent understands that if the principal fails to learn his ability via monitoring (with probability $1-m$), she will draw inferences about his ability from observed performance. Anticipating this assessment process, the agent is eager to succeed not only to obtain the bonus w_H, but also to impress the principal and to increase the chances of being retained. This incentive effect allows the principal to reduce the size of the bonus $w_H^*(I)$ as well as expected compensation $\Psi^*(I)$ when β increases.

The important point here is that the principal can influence the agent's career concern incentive and hence the cost of compensation through her choice of support. There are two effects, which I refer to as the "retention effect" and the "commitment effect". Formally, taking the first derivative of (13) with respect to I yields:

$$\begin{aligned}\frac{d\Psi^*}{dI} &= -\underbrace{a_H\left(pz_G+(1-p)z_B\right)(1-m^*)\beta}_{\text{retention effect}} \\ &\quad +\underbrace{a_H\left(p\phi(G,I)+(1-p)\phi(B,I)\right)\frac{dm^*}{dI}\beta}_{\text{commitment effect}}.\end{aligned} \tag{14}$$

In what follows, I discuss both effects in turn.

Retention effect: Holding m^* constant, offering the agent greater support not only helps him to succeed but increases the sensitivity of the agent's action to the probability of success. That is, effort and support are complements. By supporting the agent, the principal can therefore better exploit the agent's desire to retain his job as an incentive tool, which lowers the cost of compensation, Ψ^*. To be sure, when the principal offers greater support, she can lower the bonus w_H without altering effort incentives, even when the agent has no desire to stay in the firm, $\beta = 0$. Such a move, however, would not affect the expected compensation Ψ^*: for $\beta = 0$, an increase in support reduces the required bonus, but increases the probability of success and hence the probability that the agent receives the bonus, and both effects cancel each other out. Thus, the complementarity between effort and support only plays a role for the cost of the incentive plan when $\beta > 0$.

Commitment effect: Support affects the agent's effort incentive also indirectly via its impact on the principal's own monitoring incentive. When the principal chooses the level of monitoring, she trades off the benefits of making better replacement decisions with the cost of monitoring. But monitoring also affects the agent's career incentive and hence expected compensation. The agent understands that if the principal uncovers his ability via monitoring, the principal will no longer rely on performance in making assessments. Thus, when the agent anticipates a higher level of monitoring, he is less eager to work hard so as to influence the principal's perception of his ability. Due to this adverse incentive effect, the principal would like to commit to a level of monitoring that lies below the level specified in (7).[6] But the principal is unable to make such a commitment because monitoring is not observable. Any announcements to deviate from m^* are not credible. The principal can nevertheless indirectly commit to loose monitoring by adjusting the level of support. Specifically, the principal credibly signals to the agent that her subsequent monitoring incentive will be weak either by increasing the level of support, if $z_G > z_B$, or by reducing it, if $z_G < z_B$ (see Proposition 2). The anticipation of loose monitoring, in turn, spurs the agent's career incentive and reduces expected compensation. Thus, in the presence of a moral hazard problem, support plays a valuable commitment role.

Note that both the retention and the commitment effect arise only when the principal has an option to retain or replace the incumbent after the first period. In the absence of this option, either because the agent lives only for one period or because the principal cannot replace the incumbent, expected compensation Ψ^* is independent of support (see Appendix A for details and a proof).

When $z_G > z_B$, both the commitment and the retention effect work in the same direction and the cost of the pay plan Ψ^* declines with support. But for $z_G < z_B$, the two effects work in opposite directions. When the marginal cost of monitoring is low, $\gamma < \gamma_T$, the commitment effect dominates the retention effect and expected compensation increases with support. If the marginal cost of monitoring is high,

[6] The optimal level of monitoring under commitment is given by

$$m^C = m^* - a_H \left(p\phi(G, I) + (1-p)\phi(B, I)\right) U_2/\gamma,$$

where m^* is as in (7).

however, the reverse is true and expected compensation declines with support. The next proposition summarizes these results.

Proposition 4 *There is a unique threshold γ_T, determined in the appendix, such that expected compensation decreases with support, $\frac{d\Psi^*}{dI} < 0$, if $z_G > z_B$, or $z_G < z_B$ and $\gamma > \gamma_T$, and increases with support, $\frac{d\Psi^*}{dI} > 0$, if $z_G < z_B$ and $\gamma < \gamma_T$.*

4.4 Characteristics of equilibrium

I now turn to the discussion of the equilibrium levels of support and monitoring, the cost of compensation, and the agent's and principal's utilities. To do so, it is useful to consider a benchmark setting in which support has no effect on assessment, that is, $z_G^{BM} = z_B^{BM}$ (BM for benchmark), but the expected marginal effect of support on the success probability remains unchanged, $z_G^{BM} = pz_G + (1-p)z_B$. Let ($I^{BM}$, m^{BM}, Ψ^{BM}, U^{BM}, V^{BM}) denote the optimal levels that arise in this benchmark case. The next proposition shows how the values (I^*, m^*, Ψ^*, U^*, V^*) differ from the benchmark values when $z_G > z_B$ or $z_G < z_B$.

Proposition 5 *Relative to the benchmark values (I^{BM}, m^{BM}, Ψ^{BM}, U^{BM}, V^{BM}),*
(i) the principal offers greater support I^* if $z_G > z_B$ and less support if $z_G < z_B$,
(ii) the principal chooses a lower monitoring intensity, m^*, if $z_G > z_B$ and a higher intensity if $z_G < z_B$,
(iii) the agent's bonus w_H^*, expected compensation Ψ^*, and utility U^* are lower if $z_G > z_B$ and higher if $z_G < z_B$.
(iv) the principal's utility V^* is higher if $z_G > z_B$ and lower if $z_G < z_B$.

Result (i) of Proposition 5 shows that relative to the benchmark I^{BM}, the principal optimally distorts the level of support upwards if $z_G > z_B$ and downwards if $z_G < z_B$.

For $z_G > z_B$, support not only helps the agent to generate a high output in the first period (as is the case for $z_G = z_B$), but plays two additional roles. First, support allows the principal to make better performance-based replacement decisions and thus improves expected second-period performance (which is the assessment role of support discussed in Section 4.1). Second, greater support serves the principal as a tool to indirectly commit to a lower level of monitoring, which strengthens the agent's effort incentive (the commitment role discussed in Section 4.3). For $z_G < z_B$, these two effects are reversed: now, the principal has to offer *less* support to facilitate performance-based replacements and to commit to loose monitoring. In contrast, in the benchmark case with $z_G^{BM} = z_B^{BM}$, support neither plays an assessment nor a commitment role.

Part (ii) speaks to the level of monitoring. Since for $z_G > z_B$ support enables the principal to make better replacement decisions based on performance, the marginal value of monitoring is lower than in the benchmark case, which explains why $m^* < m^{BM}$. Conversely, for $z_G < z_B$, support impedes performance-based replacements, and thus increases the marginal value of monitoring, implying that $m^* > m^{BM}$.

Result (iii) demonstrates that for $z_G > z_B$ the agent's bonus, expected compensation, and utility are smaller than the benchmark values. This result follows from the observation that $I^* > I^{BM}$ and $m^* < m^{BM}$. Both the larger amount of support I^* and the smaller monitoring intensity m^* increase the agent's career incentive (see discussion in Section 4.3), which reduces the need for incentive pay and hence the agent's expected compensation and utility. These results flip when $z_G < z_B$; then, the bonus, expected compensation, and agent rents are all higher than the relevant benchmark values.

Finally, result (iv) shows that for $z_G > z_B$, the principal's utility V^* exceeds the benchmark value V^{BM}. There are two reasons for this result. First, support has the added advantage of facilitating replacement decisions based on performance and hence, holding all else constant, improves expected second-period payoffs. Second, the fact that output becomes more useful for the replacement decision mitigates the principal's temptation for monitoring, which strengthens the agent's career incentives and reduces expected compensation. Conversely, for $z_G < z_B$, support hinders performance-based replacements and increases monitoring incentives and both effects push firm value V^* below V^{BM}.

5 Applications

5.1 On the tension between the board's dual role of advising and assessing the CEO

Two key responsibilities of corporate boards are to advise their CEO as well as to assess his ability and fit and replace him if necessary. The advising role involves assisting the CEO on key decisions such as strategy and product development and providing counsel on how to execute these strategies. The two functions of the board are especially important when the CEO recently joined the firm because the new hire's ability and fit are initially uncertain. Guidance helps the CEO to succeed but, arguably, is more important for low-ability than for high-ability CEOs, that is, $z_G < z_B$. As a result, the two board roles conflict with each other because offering advice renders it harder for the board to make appropriate replacement decisions based on observed performance (Proposition 1). This tension has the following implications:

Relative to what would be optimal if advice had no assessment effect ($z_G = z_B$), the board optimally provides less guidance and acquires more information about the CEO via monitoring, the CEO's expected compensation and rent are both higher, and firm value is lower (Proposition 5).

A growing body of literature analyzes how proxies for internal governance strength such as the board's degree of independence, director equity compensation, or board size affect CEO turnover and CEO rents.[7] The current model suggests another board characteristic that influences CEO turnover and rents that is seemingly unrelated to governance: namely, the board's ability to advise the CEO, which is determined by directors' expertise and background.[8] To analyze the impact of directors' advising ability suppose that the cost of providing advice is quadratic, $C(I) = 0.5\delta I^2$, where a lower δ stands for a board with more experts. The next proposition shows how an exogenous change in the board's advising capacity δ affects board behavior, firm value, and CEO rents.

Proposition 6 *Suppose $z_G < z_B$ and $C(I) = 0.5\delta I^2$. As more expert advisors are serving on the board (δ declines),*
(i) the level of advice, I^*, increases,
(ii) the monitoring intensity, m^*, increases,
(iii) the CEO turnover-performance sensitivity declines if $z_G < \widehat{z}_B \equiv z_B \frac{1-Ga_H}{1-Ba_H}$,[9]
(iv) CEO utility, U^*, and firm value, V^*, increase.

Most of these results follow from the analysis in the previous sections. Boards

[7] See for example Faleye, Hoitash, and Hoitash (2011) and the papers cited there.

[8] See Faleye, Hoitash, and Hoitash (2013) for a paper that studies the characteristics of directors dedicated to providing strategic advice to management.

[9] The turnover-performance sensitivity is formally defined in the proof of this proposition in Appendix B.

that have more expert directors can provide useful advice at a lower cost and, consequently, do more of it. Greater board guidance facilitates value creation but renders performance less useful in assessing the CEO's ability and fit. The board responds to this impediment by acquiring more information about the CEO via monitoring, which renders the replacement decisions less sensitive to performance. A lower turnover to performance sensitivity weakens the agent's effort incentive (as discussed in Section 4.3) and increases the pressure on incentive pay, which translates into higher rents for the CEO. Firm value nevertheless increases with greater board expertise because, holding all else constant, V increases as the advising cost δ declines. A lower δ also changes the optimal level of advice but due to the envelope theorem the effect of a marginal change in I^* on V is negligible, that is, in the optimal solution, $dV/dI^* = 0$.

One implication of this analysis deserves some further attention. A widely held view is that outside directors play a key role for corporate governance because they are more independent from management than inside directors who are employees of the firm and beholden to their CEO (e.g., Bebchuk and Fried, 2004). According to this "managerial power" view, outsider-dominated boards will more frequently remove poorly performing CEOs and do a better job of preventing the CEO from extracting rents than insider-dominated boards, consistent with empirical evidence by Weisbach (1988). But outside directors may also be less capable advisors because they lack the necessary firm-specific information (e.g., Harris and Raviv 2008; Linck et al., 2008; Duchin et al., 2010). If this is the case, the present model generates similar predictions than the managerial power view: that is, an exogenous shift toward greater outsider representation on boards leads to a stronger sensitivity of turnover to performance and smaller CEO rents. However, these results do not follow here because outsiders are more independent from management; rather, the outsiders' reduced advising capacity changes the processes with which the board assesses and replaces the CEO. The model therefore suggests that the empirical finding that outsider-dominated boards exhibit a greater turnover-to-performance sensitivity does not necessarily imply that outsiders play a crucial governance role but can merely reflect the outsiders' weaker ability to offer advice.

5.2 Support and assessment in innovative environments

Tech companies such as Google support their engineers by giving them the resources, infrastructure, and, most importantly, the freedom and time to pursue innovative ideas and technologies. For example, Google, 3M, Facebook, and LinkedIn allow employees to work on company-related projects of their own choosing (Tate, 2013). Google calls this policy "20% time" and describes it in their "2004 Founders' IPO Letter" as follows[10]:

"We encourage our employees, in addition to their regular projects, to spend 20% of their time working on what they think will most benefit Google. This empowers them to be more creative and innovative. Many of our significant advances have happened in this manner. For example, AdSense for content and Google News were both prototyped in 20% time."

The idea behind 20% time is that engineers are more innovative when they have time and space to tinker and experiment. The present model provides an additional complementary advantage of this practice. Arguably, this kind of support has a greater impact on high-ability engineers with clever ideas than on low-ability engineers with poor ideas, that is, $z_G > z_B$. Thus, in addition to boosting innovation,

[10] See Google's "2004 Founders' IPO Letter" at https://investor.google.com/corporate/2004/ipo-founders-letter.html.

support serves the employer as an assessment tool because it gives high-ability employees room to separate themselves from lower-ability employees (see Proposition 5). Better assessment via output, in turn, reduces the employer's need to acquire information about ability via monitoring. These findings therefore provide an additional explanation for why tech companies such as Google "pamper" their engineers with seemingly over-the-top support and loose monitoring. In addition, Proposition 5 indicates that the high level of support and the reduced monitoring incentive allow the principal to better exploit the agent's desire to keep his job as an incentive tool. As a result, expected compensation as well as overall employee rents decline. The analysis suggests that the combination of heavy support and loose monitoring does not necessarily result in high overall employee rents when compensation contracts are derived endogenously.

Similar arguments apply for research universities. Departments typically support newly hired assistant professors by giving them the opportunity to focus on the task that matters most for the future promotion decision – research. Support comes in the form of low teaching loads and protection from time consuming committees. The model suggests that support has value not only because it increases research productivity but also because it allows the department to make better replacement decisions based on output, which, in turn, reduces the need for monitoring. Both the higher level of support and the lower equilibrium level of monitoring reduce the pressure on costly incentive pay.

5.3 Capital budgeting: Investment distortions to assess ability

Consider a capital budgeting setting in which headquarters allocates capital I to a division. Depending on the particular situation, both $z_B > z_G$ and $z_G > z_B$ seem plausible. For example, suppose the division needs capital to promote a new product. When the division manager receives a larger marketing budget, it becomes harder for headquarters to distinguish between high-ability and low-ability managers based on performance; that is, $z_B > z_G$. After all, a successful product launch is more impressive if the manager is operating on a limited rather than unlimited budget. The situation is different when headquarters allocates capital to a division for research and development purposes. Then, similar to the arguments in the previous section, investment is more productive when the manager has good rather than bad ideas, and $z_G > z_B$. Relative to an environment in which the size of the budget has no effect on assessment ($z_B = z_G$), headquarters distorts the capital allocation either downwards (in case of a marketing budget) or upwards (in case of a R&D budget) to better assess the division manager's ability based on output and to commit to loose monitoring (Proposition 5). The extant literature on capital budgeting procedures in organizations explains capital distortions as a result of the manager being privately informed about the division's investment opportunities and conflicts of interest such as empire building preferences or perk consumption (e.g., Antle and Eppen, 1985; Harris and Raviv, 1996; Bernado, Cai, and Luo, 2001). The present model offers an alternative explanation for investment distortions that is not based on managers being privately informed about their projects, but on the notion that capital allocations play assessment and commitment roles.

6 Conclusion

When an organization hires a new employee, the new hire's ability is to some extent uncertain. A key responsibility of the supervisor is to support the new employee, as well as assess his ability and decide whether to retain him or hire someone else. Depending on the context, support can come in different forms such as advice, resources, time, and freedom, but with the common goal of helping the employee to succeed in his new position. However, the two tasks of supporting the worker and assessing his ability and fit are inextricably intertwined. Support can either hamper or facilitate performance-based assessment depending on whether it has a relatively stronger marginal impact on low-ability or high-ability workers. The paper shows that the interaction between support and assessment not only leads to distortions in the optimal level of support, but also has implications for the superior's choice of monitoring, the sensitivity of turnover to performance, the worker's incentive to exert effort, optimal contracting, the worker's rents, and firm value. I consider several applications of the model to study why corporate boards that are more capable in their advisory role make CEO replacement decisions that are less sensitive to performance and "tolerate" greater CEO rents, why tech companies "pamper" their engineers with seemingly excessive support and loose monitoring, why junior faculty members are protected from high teaching loads and service, and why headquarters may find it optimal to upward distort capital allocations for R&D departments but downward distort capital allocations for marketing departments.

Appendix A - Principal does not have an option to retain or replace agent

In this appendix, I consider a benchmark setting in which the principal cannot choose whether to retain or replace the incumbent agent. For example, the agent always retires after the first period or the principal does not have the power to remove the incumbent. Regardless of whether the incumbent always leaves his position or always keeps it, expected second-period output is given by R_N as defined in (3). The principal chooses the pay plan and the level of support that maximizes expected payoffs over the two periods

$$\underset{w_H, w_L, I}{\text{Max}} V^o(I) = a_H \left(p\phi(G,I) + (1-p)\phi(B,I)\right) X - C(I) - \Psi(a_H) + R_N, \tag{15}$$

subject to the incentive compatibility and non-negativity constraints

$$U(a_H) \geq U(a_L) \text{ and } w_H, w_L \geq 0, \tag{16}$$

where

$$\begin{aligned} \Psi(a) &= a\left(p\phi(G,I) + (1-p)\phi(B,I)\right) w_H \\ &\quad + \left(1 - a\left(p\phi(G,I) + (1-p)\phi(B,I)\right)\right) w_L, \end{aligned} \tag{17}$$

is the agent's expected compensation and

$$U(a) = \Psi(a) - K(a), \tag{18}$$

is his expected utility as a function of a. The agent's participation constraint $U(a_H) \geq 0$ is always slack and hence can be ignored. Solving this problem leads to the next proposition.

Proposition 7 *If the principal does not have an option to replace/retain the incumbent, the optimal contract (w_H^o, w_L^o) and level of support I^o satisfy*

$$w_H^o(I) = \frac{k}{(a_H - a_L)(p\phi(G,I) + (1-p)\phi(B,I))}, \ w_L^o = 0, \ \textit{and} \tag{19}$$

$$I^o \ \textit{solves}\ 0 = a_H (pz_G + (1-p)z_B) X - C'(I^o), \tag{20}$$

and the agent's expected compensation and rent are

$$\Psi^o = \frac{a_H k}{(a_H - a_L)} \ \textit{and}\ U^o = \frac{a_L k}{(a_H - a_L)}. \tag{21}$$

Proof: Substituting (18) into the incentive constraint (16) and rearranging yields:

$$(w_H - w_L) \geq \frac{k}{(a_H - a_L)(p\phi(G,I) + (1-p)\phi(B,I))}. \tag{22}$$

To minimize the cost of compensation, the principal optimally sets $w_L = 0$ and chooses the level of w_H that satisfies (22) as an equation, leading to (19). Substituting the optimal payments given in (19) into the expected compensation cost function $\Psi(a_H)$ and the agent's utility function $U(a_H)$ given in (17) and (18) yields the expressions in (21). Substituting $\Psi^o = \frac{a_H k}{(a_H - a_L)}$ (from (21)) into the objective function (15) and taking the first-order condition for a maximum yields (20).

In this setting, the level of support I has no effect on the effort control problem and hence the expected cost of compensation Ψ^o. To be sure, greater support I reduces the bonus w_H^o required to induce effort, as indicated in (19), but since I also increases the probability that the agent obtain this bonus, the expected cost of compensation Ψ^o and the agent's rent U^o remain unchanged. As alluded to in Section 2, this result is a direct consequence of the assumption that the probability of success is multiplicative in effort a and $\phi(\theta, I)$. This assumption ensures that a change in support does not change the informativeness of output $x = X$ as a signal of effort a. To see this, note that the informativeness of $x = X$ about the agent's effort choice is determined by the likelihood ratio $LR \equiv \frac{P(X|a_L,\theta,I)}{P(X|a_H,\theta,I)}$, which simplifies to $LR = \frac{a_L}{a_H}$. As LR decreases, low effort has a smaller impact on output relative to high effort, and output becomes a less noisy signal about effort. Since support does not change the likelihood ratio LR, it does not affect the usefulness of output for incentive contracting purposes. However, as shown in Section 4.3, when the principal has the option to retain/replace the incumbent, support does affect the effort control problem indirectly because it changes the usefulness of output in assessing the agent's ability.

Appendix B - Proofs

Proof of Proposition 2.

Taking the first derivative on (7) with respect to I, γ, and R_Δ yields:

$$\begin{aligned} \frac{dm}{dI} &= -p\,(1-p)\,a_H\,(z_G - z_B)\,R_\Delta/\gamma, \\ \frac{dm}{d\gamma} &= -p\,(1-p)\,(1-(\phi(G,I)-\phi(B,I))\,a_H)\,R_\Delta/\gamma^2 < 0, \\ \frac{dm}{dR_\Delta} &= p\,(1-p)\,(1-(\phi(G,I)-\phi(B,I))\,a_H)\,/\gamma > 0, \end{aligned} \tag{23}$$

with $\frac{dm}{dI} < 0$ if $z_G > z_B$ and $\frac{dm}{dI} > 0$ if $z_G < z_B$.

Proof of Propositions 3.

Using (8), the effort incentive constraint $U(a_H) \geq U(a_L)$ can be written as

$$(w_H - w_L) \geq \frac{k}{(a_H - a_L)(p\phi(G,I) + (1-p)\phi(B,I))} - (1-m^*)\beta. \tag{24}$$

In the optimal solution, the incentive constraint (24) is binding and $w_L = 0$, which leads to the pay plan in (12). Using (12), the expected compensation is as given in (13).

Proof of Proposition 4.

Substituting (23) and (7) into (14) yields

$$\frac{d\Psi^*}{dI} = \\ -a_H \left((pz_G + (1-p)z_B)(1-m^*) + \frac{a_H (p\phi(G,I) + (1-p)\phi(B,I))(z_G - z_B)}{(1 - a_H(\phi(G,I) - \phi(B,I)))} m^* \right) \beta.$$

If $(z_G - z_B) > 0$ then $\frac{d\Psi^*}{dI} < 0$. If $(z_G - z_B) < 0$ then the sign of $\frac{d\Psi^*}{dI}$ depends on γ. Since $dm^*/d\gamma < 0$, there is a unique threshold, denoted γ_T, such that $\frac{d\Psi^*}{dI} > 0$ if $\gamma < \gamma_T$ and $\frac{d\Psi^*}{dI} < 0$ if $\gamma > \gamma_T$.

Proof of Proposition 5.

At the beginning of the first period, the principal chooses the level of support that maximizes the expected payoff over the two periods:

$$\begin{aligned} V(I) \equiv\ & a_H [p\phi(G,I) + (1-p)\phi(B,I)] X - C(I) \\ & + (pR_G + (1-p)R_N) - (1-m)(Q_G + Q_B) - 0.5\gamma m^2 - \Psi^*(I), \end{aligned} \tag{25}$$

where m^* and $\Psi^*(I)$ are given by (7) and (13), respectively. Taking the first-order condition for a maximum yields the optimal level of support, denoted I^* :

$$\begin{aligned} \frac{dV}{dI} &= 0 = a_H \left[pz_G + (1-p)z_B\right] X - C'(I) \\ &\quad + (1-m)p\left(1-p\right) R_\Delta a_H \left(z_G - z_B\right) - \frac{d\Psi^*}{dI}, \end{aligned} \tag{26}$$

where $\frac{d\Psi^*}{dI}$ is given in (14).

The second-order condition for a maximum is given by

$$\begin{aligned} 0 &> \frac{d^2V}{dI^2} = -\frac{d^2C(I)}{dI^2} - \frac{dm^*}{dI} p\left(1-p\right) a_H \left(z_G - z_B\right) R_\Delta \\ &\quad - 2a_H \left(pz_G + (1-p)z_B\right) \frac{dm^*}{dI} \beta, \end{aligned} \tag{27}$$

which is satisfied if $C(I)$ is sufficiently convex.

Substituting (14) into (26) yields the optimality condition:

$$\begin{aligned} \frac{dV}{dI} &= 0 = a_H \left(pz_G + (1-p)z_B\right) X - C'(I) \\ &\quad + (1-m)p\left(1-p\right) R_\Delta a_H \left(z_G - z_B\right) \\ &\quad + a_H \left(\left(pz_G + (1-p)z_B\right)\left(1-m^*\right) - \left(p\phi(G,I) + (1-p)\phi(B,I)\right) \frac{dm^*}{dI} \right) \beta. \end{aligned} \tag{28}$$

For the benchmark case with $z_G^{BM} = z_B^{BM} = \left(pz_G + (1-p)z_B\right)$, we obtain $\frac{dm^{BM}}{dI} = 0$ and condition (28) simplifies to

$$\frac{dV}{dI} = 0 = a_H \left(pz_G + (1-p)z_B\right) X - C'(I) + a_H \left(pz_G + (1-p)z_B\right)\left(1 - m^{BM}\right)\beta. \tag{29}$$

with $m^{BM} = p\left(1-p\right)\left[1 - a_H\left(G - B\right)\right] R_\Delta / \gamma$.

Parts (i) and (ii): For $z_G < z_B$, we obtain $m^* > m^{BM}$ and $\frac{dm^*}{dI} > 0$. Thus, from comparing (28) with (29), it follows that $I^* < I^{BM}$.

For $z_G > z_B$, we obtain $m^* < m^{BM}$ and $\frac{dm^*}{dI} < 0$. Thus, from comparing (28) with (29), it follows that $I^* > I^{BM}$.

Furthermore, comparing (28) with (29) shows that $|I^* - I^{BM}|$ increases as β increases.

Part (iii): Substituting $\phi(G, I) = G + z_G I$ and $\phi(B, I) = B + z_B I$, into (13) we obtain,

$$\Psi^*(I) = \frac{a_H k}{(a_H - a_L)} - a_H \left[pG + (1-p)B + (pz_G + (1-p)z_B)\, I^*\right](1 - m^*)\beta.$$

Since for $z_G < z_B$, we have $m^* > m^{BM}$ and $I^* < I^{BM}$ and since $z_G^{BM} = z_B^{BM} = (pz_G + (1-p)z_B)$, we obtain $\Psi^*(I^*) > \Psi^{BM}(I^{BM})$. Similarly, since for $z_G > z_B$, we have $m^* < m^{BM}$ and $I^* > I^{BM}$, we obtain $\Psi^*(I^*) < \Psi^{BM}(I^{BM})$.

Substituting the expected compensation (13) into the agent's utility function $U(a_H)$ given in (8) yields:

$$U = \frac{a_H k}{(a_H - a_L)} - k + pm^*\beta,$$

Since for $z_G < z_B$, we have $m^* > m^{BM}$, we obtain $U^* > U^{BM}$. Similarly, since for $z_G > z_B$, we have $m^* < m^{BM}$, we obtain $U^* < U^{BM}$.

From (12), the optimal bonus for success is given by:

$$w_H^* = \frac{k}{(a_H - a_L)\,(p\phi(G, I) + (1-p)\phi(B, I))} - (1 - m^*)\,\beta.$$

Since for $z_G < z_B$, we have $m^* > m^{BM}$ and $I^* < I^{BM}$ and since $z_G^{BM} = z_B^{BM} =$

$(pz_G + (1-p)z_B)$, we obtain $w^* > w^{BM}$. Similarly, since for $z_G > z_B$, we have $m^* < m^{BM}$ and $I^* > I^{BM}$, we obtain $w^* < w^{BM}$.

Part (iv): To proof that V^* is larger (smaller) than V^{BM} for $z_G > z_B$ ($z_G < z_B$) define $z_B = \frac{z - pz_G}{(1-p)}$ as a function of z_G, such that $z = (pz_G + (1-p)z_B)$ remains constant as z_G changes. Taking the first derivative of (25) with respect to z_G yields:

$$\frac{dV^*(I^*(z_G), z_G, m^*(I^*, z_G))}{dz_G} = \frac{\partial V^*}{\partial z_G} + \left(\frac{\partial V^*}{\partial I^*} + \frac{\partial V^*}{\partial m^*}\frac{\partial m^*}{\partial I}\right)\frac{dI^*}{dz_G} + \frac{\partial V^*}{\partial m^*}\frac{\partial m^*(I^*, z_G)}{\partial z_G} > 0,$$

which is positive because, in equilibrium, $\frac{\partial V^*}{\partial z_G} > 0$, $\left(\frac{\partial V^*}{\partial I^*} + \frac{\partial V^*}{\partial m^*}\frac{\partial m^*}{\partial I}\right) = \frac{dV^*}{dI} = 0$, $\frac{\partial m^*(I^*, z_G)}{\partial z_G} < 0$, and $\frac{\partial V^*}{\partial m^*} = \left(\frac{\partial V_2^*}{\partial m} - \frac{\partial \Psi^*}{\partial m}\right) < 0$, with $\frac{\partial V_2^*}{\partial m} = 0$ and $\frac{\partial \Psi^*}{\partial m} > 0$. Thus, when z_G increases and z_B declines such that $z = (pz_G + (1-p)z_B)$ stays constant, V^* increases.

Proof of Proposition 6.

Parts (i) and (ii): Result (i) immediately follows from (26) and result (ii) follows because $\frac{dm}{dI} > 0$ for $z_B > z_G$ (see Proposition 2).

Part (iii): The turnover-performance sensitivity is defined as[11]

$$TPS = P(TO|x = 0) - P(TO|x = X), \tag{30}$$

where

$$\begin{aligned} P(TO|x &= 0) = (1-m) + mP(\theta = B|x = 0), && (31)\\ P(TO|x &= X) = mP(\theta = B|x = X). && (32) \end{aligned}$$

[11]Defining the turnover-performance sensitivity as the probability of replacement after poor performance, $P(TO|x = 0)$, does not change the result in Proposition 6(iii).

The term in (31) represents the probability that the board removes the incumbent when performance is poor and can be explained as follows. After a weak performance, $x = 0$, the board will replace the CEO with certainty if it did not obtain any additional information via monitoring, which happens with probability $1 - m$. With probability m the board has learned the incumbent's ability. Conditional on $x = 0$, the board has learned that the incumbent has low ability with probability $P(\theta = B|x = 0)$, in which case the board replaces him. The term in (32) can be explained in a similar fashion. When performance is high, $x = X$, the board only replaces the incumbent if it has uncovered that he has low ability, which is the case with probability $mP(\theta = B|x = X)$.

Taking the first derivative of (30) yields:

$$\begin{aligned} \frac{dTPS}{dI} &= -\frac{dm}{dI}\left[1 - \left(P(\theta = B|x = 0) - P(\theta = B|x = X)\right)\right] \\ &\quad + m\left(\frac{dP(\theta = B|x = 0)}{dI} - \frac{dP(\theta = B|x = X)}{dI}\right). \end{aligned} \tag{33}$$

Using (4) and (5) we obtain:

$$\begin{aligned} \frac{dP(\theta = B|x = 0)}{dI} &= -a_H\left(1 - p\right)\frac{(z_B - z_G) - a_H\left(z_B\phi(G, I) - z_G\phi(B, I)\right)}{\left(1 - a_H\left(p\phi(G, I) + (1 - p)\phi(B, I)\right)\right)^2}p, \\ \frac{dP(\theta = B|x = X)}{dI} &= p(1 - p)\frac{z_B\phi(G, I) - z_G\phi(B, I)}{(p\phi(G, I) + (1 - p)\phi(B, I))^2}. \end{aligned}$$

From $z_B > z_G$ and $\phi(G, I) > \phi(B, I)$, it follows that $\frac{dP(\theta=B|x=X)}{dI} > 0$. $\frac{dP(\theta=B|x=0)}{dI}$ can either be positive or negative. Using $\phi(G, I) = G + z_G I$ and $\phi(B, I) = B + z_B I$, we can write

$$H \equiv (z_B - z_G) - a_H\left(z_B\phi(G, I) - z_G\phi(B, I)\right)$$

as

$$H = (z_B - z_G) + a_H (Bz_G - Gz_B).$$

H is positive if $z_G < z_B \frac{1-Ga_H}{1-Ba_H}$. Thus, for $z_G < z_B \frac{1-Ga_H}{1-Ba_H}$ we obtain $\frac{dP(\theta=B|x=0)}{dI} < 0$.

The expression in the first line of (33) is negative because $\frac{dm}{dI} > 0$ for $z_B > z_G$ (see Proposition 2) and because the term in square brackets is positive. The expression in the second line of (33) is also negative because $\frac{dP(\theta=B|x=X)}{dI} > 0$ and, for $z_G < z_B \frac{1-Ga_H}{1-Ba_H}$, $\frac{dP(\theta=B|x=0)}{dI} < 0$. Thus, for $z_G < z_B \frac{1-Ga_H}{1-Ba_H}$, we obtain $\frac{dTPS}{dI} < 0$.

There are two forces that explain these results. First, for $z_G < z_B$, an increase in advice reduces the usefulness of output in assessing ability and hence increases the incentive to acquire information via monitoring. A higher monitoring intensity, in turn, reduces the need to base the replacement decision on firm performance and thus reduces the turnover-performance sensitivity. Second, holding m constant, an increase in I affects the probability that the board receives "conflicting" evidence in the sense that she uncovers good (bad) news via monitoring but firm performance is low (high). For $z_G < \widehat{z}_B$, an increase in I increases the probability of "conflicting" evidence, which further reduces the turnover-performance sensitivity.

Part (iv): To determine the CEO's utility, substitute the expected compensation determined in (13) into $U(a_H)$ given in (8), which yields:

$$U(a_H) = \frac{a_H k}{(a_H - a_L)} - k + pm^* \beta,$$

Taking the first derivative gives

$$\frac{dU(a_H)}{dI} = p\frac{dm^*}{dI}\beta > 0,$$

which is positive since $\frac{dm^*}{dI} > 0$ for $z_B > z_G$.

Finally, taking the first derivative of the principal's utility given in (25) with respect to δ yields:

$$\frac{dV^*}{d\delta} = \frac{\partial V^*}{\partial \delta} + \frac{dV^*}{dI}\frac{dI}{d\delta} = \frac{\partial V^*}{\partial \delta} < 0,$$

which is negative because, in equilibrium, $\frac{dV^*}{dI} = 0$, and $\frac{\partial V^*}{\partial \delta} = -0.5I^2 < 0$.

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